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An Economic Analysis of Investment in the United States Shipbuilding Industry

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Abstract

Amidst the global economic recession of recent years and sizeable injections of federal stimulus packages, the Navy's budget for ship construction (SCN) has experienced only modest real growth. While both the 2010 Quadrennial Defense Review and the 30-year shipbuilding plan have reaffirmed a fleet size goal of 313 ships, some suggest that $20 billion or more per year is needed to attain these fleet numbers. This research has analyzed the United States' shipbuilding industry as a potentially rewarding source of economic stimulus and benefit through similar or identical measures used by economists at Oxford Economics. First, direct and indirect (supply-chain) monetary impacts from the "shipbuilding and repair" sector were analyzed using US Bureau of Economic Analysis input/output data and a Carnegie-Mellon University model of a Leontief inversion process. This sector was then compared with five alternative investments. Second, the direct and indirect benefits of the shipyard-related labor market was analyzed using data collected from the Bureau of Economic Analysis, Naval Sea Systems Command, and the American Shipbuilding Association. Finally, measures of Capital Intensity and Capacity were applied to the financial statements of the nation's largest private owners of shipyards— General Dynamics and Northrop Grumman. The results suggest that US shipbuilding generates benefits comparable to alternative investments, while supporting more labor, and highly skilled jobs, than alternatives. In addition, high levels of capital intensity in shipbuilding suggest that a decline in demand may yield a permanent loss of US productive capacity. Finally, excess capacity throughout the industry shows a clear ability to absorb an increase in demand, providing prompt and immediate impact on sustained economic recovery.

Introduction

Purpose of Study

In 2008 and 2009, the United States' economy has struggled with what has widely been described as "the worst economic crisis since the Great Depression." Specifically, the national economic data shows a reduction of 1.7 % in real gross domestic product (GDP), measured in constant 2005 dollars, since the beginning of calendar year 2008 (Bureau of Economic Analysis, 2009). Although this contraction may seem slight, this is the first six-quarter period since 1982 that the national GDP growth has been negative. Now, with the nationwide unemployment rate near 10%, the United States has lost over 7.3 million jobs since the start of the damaging recession (Homan, 2009). Some economists are predicting recovery in 2010, but national leaders and decision-makers continue to look to federal government spending as a means of stimulating job growth, injecting stability, and sustaining recovery.

In a series of efforts to mitigate drastic economic decline, the US Congress passed a $700 billion *Troubled Asset Relief Program* (TARP) package in October of 2008, followed by a $787 billion *American Recovery and Reinvestment Act* on February 13th, 2009 (Recovery.gov, 2009). Of the initial TARP package, about $550 billion has been committed to various financial firms, banks, and institutions throughout the country; so far, $70.1 billion has been returned to the Treasury (Ericson, He & Schoenfield, 2009). The Federal Reserve and the White House continue now to seek proper locations for depositing large sums of federal dollars as a means of ensuring continued consistent recovery of our national economic forecasts. Just as recently as December of 2009, the *New York Times* featured a front-page article in which White House economist Jared Bernstein suggests that the administration is considering an additional $150 billion in stimulus spending, of which $50 billion could be invested "in infrastructure projects alone such as roads, bridges, and water projects" (Pace, Taylor & Elliott, 2009). Clearly, national leaders are convinced that boosting federal spending is one of the best tools for ensuring that America's $14.3 trillion[1] economy remains healthy and growing at a stable, sustainable pace. The questions now being discussed in various offices and conference rooms throughout Washington, DC, and the country as a whole include robust debates about where to invest these funds. What effects would a $1 trillion health care package have on our weakened economy? Where are the benefits of the *American Recovery and Reinvestment Act;* where have they manifested? The executive branch claims to track every dollar spent under this $787 billion umbrella, but how is that spending really benefiting the economy? Other, perhaps equally important, questions exist for industries and sectors yet to benefit from federal spending packages and stimulus measures—what *could* investments in those sectors be doing to improve the economy?

One important industry that has not received direct funding from government intervention in the current recession has been the US shipbuilding sector. A website search for "shipbuilding" at the federal government's website designed to provide transparency to American citizens reveals that a mere $132,000 of the $787 billion package has been allocated to a company called Horizon Shipbuilding in Alabama (Recovery.gov, 2009).[2] This $132,000 payment from the Department of Transportation is the only search result; clearly, the outcome demonstrates that not even one tenth of one percent of the *American Recovery and Reinvestment Act* has been invested in shipbuilding companies.

[1] Based on gross domestic product (GDP), seasonally adjusted, annualized amount for 3rd quarter 2009, from the Bureau of Economic Analysis (www.bea.gov)

[2] Search was conducted at www.recovery.gov, whose stated mission statement is to "provide easy access to data related to *Recovery Act* spending and allow(s) for the reporting of potential waste, fraud, and abuse."

Those with an interest in the US shipbuilding industry believe that their particular sector of manufacturing has a significant ability to provide economic stimulus, or substantial return-on-investment for national decision-makers and taxpayers alike. The purpose of this thesis study is to determine, *what is the return or benefit to the US national economy for federal expenditures in the shipbuilding sector*? Common economic models, discussed in detail in the pages that follow, will be applied to pertinent sector data in order to answer this important question. As politicians seek to stimulate and sustain US economic growth, they hope to create or maintain jobs, expand national gross domestic product, and provide a lasting resource for future economic potential; investments in shipbuilding ardently accomplishes all three goals, as this study will seek to demonstrate.

Problem

Problem 1: US Navy Fleet Size: An Uncharted Goal

The Chief of Naval Operations (CNO) has repeatedly affirmed a commitment to a United States' naval fleet of at least 313 warships (McIntire, 2009). However, in the FY 2011 30-year shipbuilding plan, the US naval fleet does not include 313 ships until the year 2020 (Director, Warfare Integration (OPNAV N8F), 2010). One profound problem is the sharp discrepancy between these CNO estimates of national needs for our naval fleet, versus the projected fleet decline if funding for ship construction remains constant in real dollars. An estimate from the American Shipbuilding Association suggests that our fleet could reach a mere 180 ships total if additional funding for ship construction is not received.[3] Another study by the Center for Strategic and Budgetary Assessments (CSBA), suggests that the Congressional appropriation for "Shipbuilding and Conversion, Navy (SCN)" would have to be funded to levels of about $20.4 billion in order to achieve the Navy's desired force structure in future years (Work, 2009). Moreover, the same CSBA study references recent Congressional Budget Office estimates that a total of $22.4 billion per year would be required to reach a fleet size of 313 ships. In stark contrast to these projected levels for achievement of the CNO's fleet size goal, $12.7 billion was the total funding of the fiscal year 2009 SCN account; based on CSBA estimates, the effort was underfunded by about 35% (Department of the Navy, 2008). Additionally, throughout 2040, "to be consistent with expected future defense budgets, the Department of the Navy's annual shipbuilding construction (SCN) budget must average no more than $15.9 billion per year in FY2010 dollars" (Director, Warfare Integration (OPNAV N8F), 2010).

[3] The prediction is captured in the "unilateral Navy trends" graph, acquired from the American Shipbuilding Association, December 2009. Included on next page.

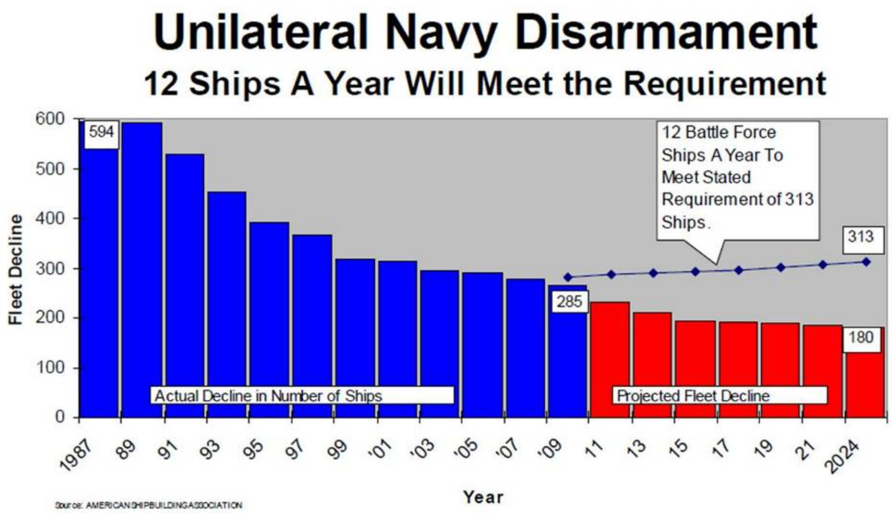

Figure 1. Unilateral Navy Disarmament

In summary of the first disconnect between projected fleet needs and recent funding of ship construction, the ostensible likelihood is that, barring any geopolitical events that may punctuate the national security equilibrium, the United States Navy is not likely to reach a fleet of 313 ships before the year 2020. In addition, the academic and practical arenas of shipbuilding cost growth and projected fleet size funding estimates have been thoroughly explored by talented minds with reliable experience. For these reasons primarily, this thesis study will not explore issues of (1) appropriate fleet size to meet national security needs, or (2) the rising costs of ship construction as it impacts efforts to reach projected needs. Although both of these issues are considered important, thorough and credible studies by congressional experts such as Mr. Ron O'Rourke[4], RAND, and others have been and currently are being conducted within these arenas; this thesis will focus elsewhere.

Problem 2: What Does Shipbuilding Do for the Economy? How?

A second important problem exists within these topics of US naval fleet size, national economic woes, and ship construction—one more obscure, and perhaps with a solution more potentially rewarding. The question referred to is this: what are the economic benefits of building ships? When comparing alternative options for investment of federal taxpayer dollars, building highways versus bailing out banks for example, several important questions appear at the forefront of consideration. First, what is the health and capacity of the industry being considered for receipt of billions of dollars? Could the sector accept the billions of dollars of additional funding and apply them in some meaningful manner to an economic benefit of others? Are there vendors or resources whose financial health depends upon the sector considered? For instance, building highways requires not only large pools of available labor, but also purchases from blacktop/concrete producers, perhaps equipment rentals for steamrollers and forklifts, and other suppliers who would benefit from increased demand of their products. Are there similar supply-chain benefits for the builders of ships?

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[4] Mr Ronald O'Rourke is a "specialist in naval affairs" with the Congressional Research Service, and has published numerous studies regarding the rising costs of Navy ships for the US Navy, as well as analysis of other nation's ships procurement programs; most are available at www.crs.gov.

Investments of federal tax dollars should be allocated to the sectors where it would economically benefit the most people, or maximize the return-on-investment for the federal government.

When evaluating a particular industry for its ability to benefit national economic recovery and growth, one should consider the channels through which the benefits manifest. In determining channels of impact, quantitative multipliers may be calculated. Once a trusted and scrutinized economic multiplier is available for each investment option, public sector decision-makers could be as well informed as private sector investment bankers or venture capitalists, who seek to deposit their wealth where it will multiply the greatest, earn the most rewards, and pay dividends to their stakeholders for future periods. The national politicians seeking stabilization and growth of the US economy could evaluate their problem of economic return for various courses of investment using a similar framework; their stakeholders are all US citizens, and their wealth is the measure of national GDP.

Organization of Thesis Study

What's Not Included, and Why?

In both quantitative and qualitative analysis, this study will consider only the "US shipbuilding industry" investment option available to policymakers. One aspect of the study's contribution to national information regarding economic investment in shipbuilding will be found in its analysis of the *lifecycle benefit* of a vessel's national economic impact. Much detailed research has been conducted already in an effort to capture and quantify *lifecycle costs* of ship procurement programs. Thus, issues of rising construction and procurement costs of Navy ships will not be a focus of this study. Rather, *lifecycle benefit to the regional and national economy* will be explored, quantified where possible.

Both the 2010 *Quadrennial Defense Review (QDR)* and the Navy's 30-year shipbuilding plan were completed in February of 2010. The mix of vessels to be procured has been planned, and evaluation of shipbuilding costs is being thoroughly scrutinized by national authorities on the subject such as Ronald O'Rourke, with the *Congressional Research Service*. With the *QDR* and the 30-year shipbuilding plan both published along with the President's Fiscal Year 2011 Budget in February, much light has been shed on the path ahead for US shipbuilding and naval fleet size. This thesis study will not attempt to make a contribution to the analysis of rising ship costs, proper mix and type of vessels to be procured, or consideration of the national funds available for ship construction. Rather, the study will focus on (1) in what ways, and (2) how the shipbuilding industry benefits regional economies and the national economic health.

Methodology

General Approach

In a September 2009 study entitled The Economic Case for Investment in the UK Defense Industry, researchers and economists at Oxford Economics in London developed a detailed framework for analyzing the economic contribution of various industries (Oxford Economics, 2009). This study will use much of the Oxford study's framework as it analyzes the economic returns of the "shipbuilding and repair" sector through at least four lenses:

- Monetary impact – using input/output analysis to analyze the direct and indirect channels of the shipbuilding's sector on the US economy

- Labor market impact – jobs supported by US shipbuilding, and the relative skill levels of those jobs; the regional distribution of those jobs throughout the country
- Capital Intensity – "sectors that invest the most in capital and labor present the largest potential for losses if they fail" (Oxford Economics, 2009).
- Capacity measures & a rapid return? – "in order for an increase in Government procurement to have an immediate impact on the economy a sector must have sufficient spare capacity to absorb the additional demand" (Oxford Economics, 2009).

In order to best understand the methodology used by Oxford Economics, meetings were held at the London Office in December of 2009, with the two economists who were mainly responsible for the study's content—Mr. Andrew Tessler and Mr. Pete Collings. Additionally, interviews were conducted with US acquisition professors, shipbuilding industry leaders, and several distinguished economists both within and outside of the US Department of Defense.

"Free Market" Concerns

In several months of research and interviews with various economists, some have expressed fundamental ideological concerns regarding the use of government spending as a means of stimulating the economy. The idea that government spending creates a multiplier effect for economy benefit was based on the economic theory of John Maynard Keynes, and published by Richard Kahn in 1931 (Kahn, 1931). Much academic debate and theory continues to permeate today's economics. In today's environment, a prominent professor of economics at Harvard University, Mr Robert Barro, has conducted research demonstrating that there is "no evidence of a Keynesian multiplier effect" for stimulus spending, and has published his view that "defense-spending multipliers exceeding one likely apply only at very high unemployment rates, and nondefense multipliers are probably smaller" (Redlick, 2009). Still other prominent economists disagree about the beneficial effects of Keynesian spending. The *Journal of Post Keynesian Economics* exists where scholars can publish their research and works based on the theories of Keynesian multipliers and Keynes' ideas of stimulus.

One distinguished economist with Stanford University's Hoover Institute and others with the Naval Postgraduate School have suggested that the United States Government could acquire ships more efficiently (at a lower cost) by allowing them to be produced overseas, where there may be a comparative advantage for ship construction. Although perhaps economically sound, national decision-makers widely agree that US national security requires maintaining the ability to build warships on American soil. Once agreed that the capability to produce US warships on American soil is vital to US national security interests, the benefits, or economic returns of doing so ought to be well known. In the *Journal of Post Keynesian Economics*, findings published in 2005/2006 reveal that "a rise in defense spending had a favorable impact on GDP and employment, but led to larger trade and budget deficits" (Atesoglu, 2005-6). Although there is much political and economic debate on the merits of government spending and investment, this research will build upon the work of credible, established Nobel laureate economists[5], and closely follow the methodology employed by researchers at Oxford Economics.

Monetary Impact—Multipliers: Direct, Indirect, Induced

Input/Output Analysis

Input-output economic analysis is a Nobel Prize-winning analytical framework developed by Professor Wassily Leontief in the late 1930s (Miller & Blair, 1985). All economic activity within a country is divided into sectors or industries. In the United States, those sectors are identified using the North American Industrial Classification System (NAICS) codes.[6] Inter-industry transactions are then measured for a specific time period (one year) in constant monetary terms (the US dollar). The results, known as benchmark data, are represented in a matrix consisting of outputs listed in rows, and inputs listed in columns. The format allows analysis of how one industry's outputs are dependent upon inputs from all other sectors of the economy. The United States' Bureau of Economic Analysis last collected such economy-wide benchmark data for the US economy in 2002; a revised version was last published in April 2008 (Bureau of Economic Analysis, 2008).

Once in possession of benchmark economic data for the economy as a whole, a series of specific steps may be performed in order to identify a specific sector's impact on the economy. First, the flow from sector *i* to sector *j* is defined as z_{ij}. Next, the variable X_j is chosen as the total gross output of the individual sector *j* in the given year. From these variables, a technical coefficient, a_{ij} is calculated as:

$$a_{ij} = \frac{z_{ij}}{X_j}$$

The resulting coefficient then represents the dollar value of inputs from sector *i* required for every dollar of output from sector *j*. The system is designed as to provide constant returns to scale. In other words, a_{ij} is a fixed relationship; when output from sector *j* is doubled, it is assumed that the inputs required from sector *i* would also be doubled. Economies of scale in production are thus ignored; the Leontief system is strictly a linear model. Furthermore, the inter-industry flows from *i* to *j* for a given year depend entirely and exclusively on the total output of sector *j* for that specific year (Miller & Blair, 1985).

Rather than manually performing the matrix algebra required to analyze the impacts of a certain sector, a software model developed by researchers at Carnegie Mellon University performs a Leontief inverse on the portion of the larger matrix pertinent to the sector chosen. The model, originally created in 1995, is called Economic Input-Output Life Cycle Assessment (EIO-LCA), and is "comprised of national economic input-output models and publicly available resource use and emissions data" (Carnegie Mellon, 2008). Only the economic results will be used in this study; the environmental impact will not be considered.

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[5] Wassily Leontief received "The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1973," Paul Krugman, who widely agrees with Keynes' theories, received the prize in 2008.

[6] NAICS is the "standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the US business economy."

With a credible reputation based on the Nobel Prize winning theory of Wassily Leontief and reliable data from the BEA, "the EIO-LCA method has been applied to economic models of the United States for several different years, as well as Canada, Germany, Spain, and select US states." The on-line tool has been accessed over 1 million times by researchers, LCA practitioners, business users, students, and others." Additionally, the input-output analysis method has been "used extensively for planning throughout the world" (Carnegie Mellon, 2008).

Direct & Indirect Multipliers

By considering various channels of impact, economic multipliers may be calculated for three distinct areas of the shipbuilding industry's overall economic impact: direct effects, indirect effects, and induced effects. Direct impacts are employment and activity in the sector itself—US shipbuilding. Indirect impacts are defined as "employment and activity supported down the supply chain, as a result of a sector's companies purchasing goods and services from" suppliers (Oxford Economics, 2009). For example, when a shipyard is building a new Littoral Combat Ship (LCS), it may order a fire-control system to be installed that was designed in California. That same system may have been built with components from Washington State. The purchase of various equipment and supplies from vendors, as well as jobs and sales at those vendors' offices may be quantified as indirect impacts for investment in the shipbuilding industry. Finally, *induced* impacts are also of economic importance to the study of ship construction. Oxford Economics defines induced impacts as "employment and activity *supported by the consumer spending* of those employed in the sector or in its supply chain." For instance, the manufacturer of a component ordered by the shipyard for construction of a new vessel has additional revenue from the sale of that component; he spends this revenue in his local economy buying everyday goods and services, which increases benefits to local economic growth. This induced analysis considers a wide variety of industries and activities throughout the United States, and relies on creation of an economic multiplier for its quantification.

Other Sectors to be Compared

The "shipbuilding and repairing" sector will henceforth be referred to simply as the "shipbuilding" industry. Per NAICS labeling, shipbuilding is a sub-sector of the (336xxx) group labeled "vehicles and other transportation equipment." Comparisons of Leontief model output will be analyzed and contrasted with five other sectors of the US economy:

- Automobile manufacturing (336111)
- Aircraft manufacturing (336411)
- Military Armored Vehicles and tank parts manufacturing (336992)
- Nonresidential manufacturing structures (230102)
- Health care: offices of physicians, dentists, health care practitioners (621A00).

These five sectors were chosen to include three other subcategories of manufacturing transportation vehicles, a more general manufacturing alternative, and also a service-based industry for comparison.

Estimation of Induced Multipliers

In addition to the direct and indirect economic effects to be calculated using the Carnegie Mellon model, *induced* effects should also be considered and quantified. The induced impacts of activity within a sector are “employment and activity supported by the consumer spending of those employed in the sector or in its supply chain. This helps to support jobs in [US] industries that supply these purchases and includes jobs in retail outlets, companies producing consumer goods and in a range of service industries” (Oxford Economics, 2009). Since the induced effects are the most difficult to quantify, data from previous studies of US and UK shipbuilding industries will be reviewed. Based on the recommendation of economist Andrew Tesller at Oxford Economics, the induced multiplier for US shipbuilding will be estimated as a fraction of the indirect multiplier. Based on the ratio of induced effects to indirect effects for similar studies, as well as the basic consumption multiplier, this research will lead to an inference about a reasonable range of an induced multiplier for US shipbuilding.

Estimations of Employment Supported

Based on the work of Garnick and Drake in the 1970s, the Bureau of Economic Analysis (BEA) has published a handbook for users of its Regional Input-Output Multipliers System (LECG, LLC, 2002)[7]. The process of using the BEA’s system to derive regional multipliers is summarized concisely in the 2002 LECG report for the American Shipbuilders Council:

> The RIMS II method for estimating regional Input-Output multipliers can be viewed as a three-step process. In the first step, the producer portion of the national Input-Output table is made region-specific by using four-digit SIC location quotients (LQ's). The LQ's estimate the extent to which input requirements are supplied by firms within the region. RIMS II uses LQ's based on two types of data: BEA's personal income data (by place of residence) are used to calculate LQ's in the service industries; and BEA's wage-and-salary data (by place of work) are used to calculate LQ's in the nonservice industries.
>
> In the second step, the household row and the household column from the national Input-Output table are made region-specific. The household row coefficients, which are derived from the value-added row of the national Input-Output table, are adjusted to reflect regional earnings leakages resulting from individuals working in the region but residing outside the region. The household column coefficients, which are based on the personal consumption expenditure column of the national Input-Output table, are adjusted to account for regional consumption leakages stemming from personal taxes and savings.
>
> In the last step, the Leontief inversion approach is used to estimate multipliers. This inversion approach produces output, earnings, and employment multipliers, which can be used to trace the impacts of changes in final demand on directly and indirectly affected industries.

Rather than manually performing the matrix algebra and Leontief inversion, the results of the Carnegie-Mellon Economic Input-Output Life Cycle Assessment model will

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[7] Regional Input-Output Multipliers System (RIMS II) is explained in Appendix C of the 2002 LECG report.

once again be utilized. The process allows for a distinct number of jobs to be calculated for each dollar amount of increased output from a sector.

Labor Market Impact

Highly Skilled Jobs

Many of the workers involved in ship construction, and modernization have been training for years to earn the specific qualifications necessary to perform those tasks. To be a nuclear plant welder in the United States, for example, "one must be cleared by the FBI, undergo drug and alcohol testing, and pass a psychological screening. These criteria are above and beyond welding certification, diving certification, and special training required of all nuclear plant personnel (Hancock, 2003)." The nuclear welders and construction personnel who build our aircraft carriers and submarines are not an immediately renewable resource. In other words, if they are eliminated from the workforce due to drastic drops in demand for their services at the "big six" shipyards, then there are at least two formidable and unfavorable results. First, if the US military suddenly has an increased demand for specialized labor in nuclear or conventional ship construction (war), then we will not have that capacity available to be utilized. We may have to actually outsource those jobs to other country, which is particularly dangerous and difficult in matters of national security and weapons systems construction. Secondly, the atrophy of the workers' skills in industry combined with the graying of the workforce may actually lead to a regression of the "knowledge economy" of this sector of the US defense and shipbuilding industries, leading to a larger-scale contraction (National Defense Research Institute (RAND), 2006). The principle of a knowledge economy is, in brevity, explanation of the use of knowledge itself as a product or tool producing an economy benefit (Drucker, 1992). For instance, the training, experience, and skill-level of an individual welder or shipyard worker has some inherent economic value, which can be quantified in calculating the sum of the industry or activity's economic worth.

Capital Intensity and Excess Capacity—"What If?"

In researching the unique aspects of the US shipbuilding industry as it compares to other defense activities, Dr. Nayantara Hensel, a former professor at The Naval Postgraduate School and currently Chief Economist in the Assistant Secretary of the Navy (Financial Management & Comptroller Office) highlighted the high capital intensity and sunk investments of infrastructure existing within the shipbuilding sector. The facilities and infrastructure themselves become "economic waste" if the existing capacity is not utilized by providing an appropriate demand signal (Hensel, 2009). The same principle is summarized nicely in the Oxford Economics report on investment in the UK defense industry: "sectors that invest the most in capital and labour present the largest potential for losses, if they fail." In summary, unlike shopping malls and retail centers, shipyards (as they are highly both capital and labor intensive) are unable to be readily converted to some other economic activity, if they fail. Rather, they become "waste." There is, therefore, an inherent opportunity cost of failing to utilize the existing capacity—the current market values of the facilities and technology themselves. Acceptance of this principle that irrevocable waste results from failure to utilize sectors with high capital intensity, combined with the clear evidence of the shipbuilding industry's investment in capital plants and equipment, supports the claim that basic funding levels to sustain the industry's existence at current levels is economically viable and preferable (Booth, Colomb & Williams, 2008).

Using public data from the released “10k” financial statements, capital intensity will be calculated as:

$$\frac{net\ capital\ stock}{revenue\ for\ 2009}$$

This ratio provides “a measure of a firm's efficiency in deployment of its assets, computed as a ratio of the total value of assets to sales revenue generated over a given period. Capital intensity indicates how much money is invested to produce one dollar of sales revenue.” Moreover, “a decline in a capital intensive industry may mean a permanent loss of productive capacity” (Oxford Economics, 2009).

Capacity Measures and a Rapid Return?

“In order for an increase in Government procurement to have an immediate impact on the economy a sector must have sufficient spare capacity to absorb the additional demand” (Oxford Economics, 2009). Published data from the US Department of Commerce, Bureau of Economic Analysis, and corporate “10k” financial statements will be collected and analyzed in order to determine if the US shipbuilding industry could absorb an increase in demand and provide a timely return for investment.

Results

Input/Ouput Multiplier Analysis

Carnegie Mellon University’s Economic Input-Output Life Cycle Assessment (EIO-LCA) model was used to perform a Leontief inverse solution based on 2002 US Benchmark data from the Bureau of Economic Analysis (BEA), with the following results obtained (Carnegie Mellon, 2008). First, it should be noted that the latest United States Benchmark data from the Bureau of Economic Analysis is 2002 data that was last updated in 2008. The model’s software calculates a coefficients matrix based on the input-output data for the US economy. By isolating a single sector of the economy, and choosing a given level of output or production from that sector, direct and indirect economic activity estimates are generated. The “shipbuilding and repair” sector (NAICS code 336611) was selected for analysis, with a presumed increased production from that sector of $100 million. In other words, an injection of $100 million was entered into the model. One possible source of an additional ship production demand of $100 million would be government orders for US Navy vessels. However, this particular model makes no distinction between military and civilian contracts, nor between Navy and commercial shipbuilding. If the market were to demand an additional $100 million in commercial ship construction, the economic activity estimates would be the same. Since the Leontief function is a linear model, output results will vary proportionally with those generated below. Indeed, Leontief models are always linear (Leontief, 1966). For instance, entering a $1 billion increased demand output in to the model will yield results that are ten times higher than those below, while inputting $50 million will yield results that are half of those below.

Table 1. Total and Direct Economic Effects of $100 Million Output from “ShipBuilding and Repairing” Sector

NAICS code	Sector Description	Total Economic ($ mil)	Direct Economic ($ mil)
	Total for all sectors	*209.*	*157.*
336611	Shipbuilding and repairing	99.9	99.9
420000	Wholesale trade	6.7	3.6
550000	Management of companies and enterprises	6.5	3.4
333618	Other engine equipment manufacturing	5.6	4.9
331110	Iron and steel mills	3.3	1.7
533000	Lessors of nonfinancial intangible assets	3.1	2.4
541610	Management consulting services	2.5	1.8
52A000	Monetary authorities and depository credit intermediation	2.4	1.2
523000	Securities, commodity contracts, investments	2.18	1.33
531000	Real estate	2.15	0.407

Direct Economic Effects

In the first row of the above Table 1, labeled “total for all sectors,” direct economic effects of $157 million represent the dollar amounts of purchases made by the “shipbuilding and repairing” sector in order to manufacture its final product (a ship). This $157 million includes the input value of $100 million increased economic activity for the shipbuilding and repairing sector, which is shown (minus rounding error of 0.1) in the second row of the table. So, the sector purchases $57 million worth of products (goods and services) from other sectors in order to make $100 million worth of output.

The shipbuilding and repair sector ranks third of the six sectors considered, when ranked by direct economic effects, as shown in table IV-2 below:

Table 2. Direct Economic Impact of an Additional $100 Million Output from Sector

Sector #	Sector Description	Direct Economic Impact
336111	automobile manufacturing	$174
336411	aircraft manufacturing	$165
336992	mil. Armored vehicles & tank parts manufacturing	$160
336611	shipbuilding and repairing	$157
230102	nonresidential manufacturing structures	$141
621A00	offices of physicians, dentists, health care practitioners	$135

Value Added

The difference between the $100 million output from shipbuilding and the $57 million of inputs it requires is the value added by the "shipbuilding and repairing sector" itself. The value added represents "compensation of employees, taxes on production and imports less subsidies, and gross operating surplus. Value added equals the difference between an industry's gross output ($100 million) minus the cost of its intermediate goods that are purchased (such as energy & raw materials)" (Carnegie Mellon, 2008). For instance, once the raw materials and services are purchased from other sectors, the value of the skilled labor and contribution from the shipyards themselves totals $43 million. Stated differently, the $43 million in value added is one (direct) component of an increase in Gross Domestic Product (GDP) as a result of the additional $100 million of output.

Table 3 and Figure 2 below show the value added (contribution to GDP) by sector of the US economy considered, for a $100 million increased output from that sector. The shipbuilding sector ranks fourth of the six sectors considered, when ranked by economic value added.

Table 3.

Sector #	Sector Description	Increased Production Output	Amount of Direct Purchases	Value Added (difference)
336111	automobile manufacturing	$100	$74	$26
336411	aircraft manufacturing	$100	$65	$35
336992	mil. Armored vehicles & tank parts manufacturing	$100	60	$40
336611	shipbuilding and repairing	$100	$57	$43
230102	nonresidential manufacturing structures	$100	$41	$59
621A00	offices of physicians, dentists, health care practitoners	$100	$35	$65

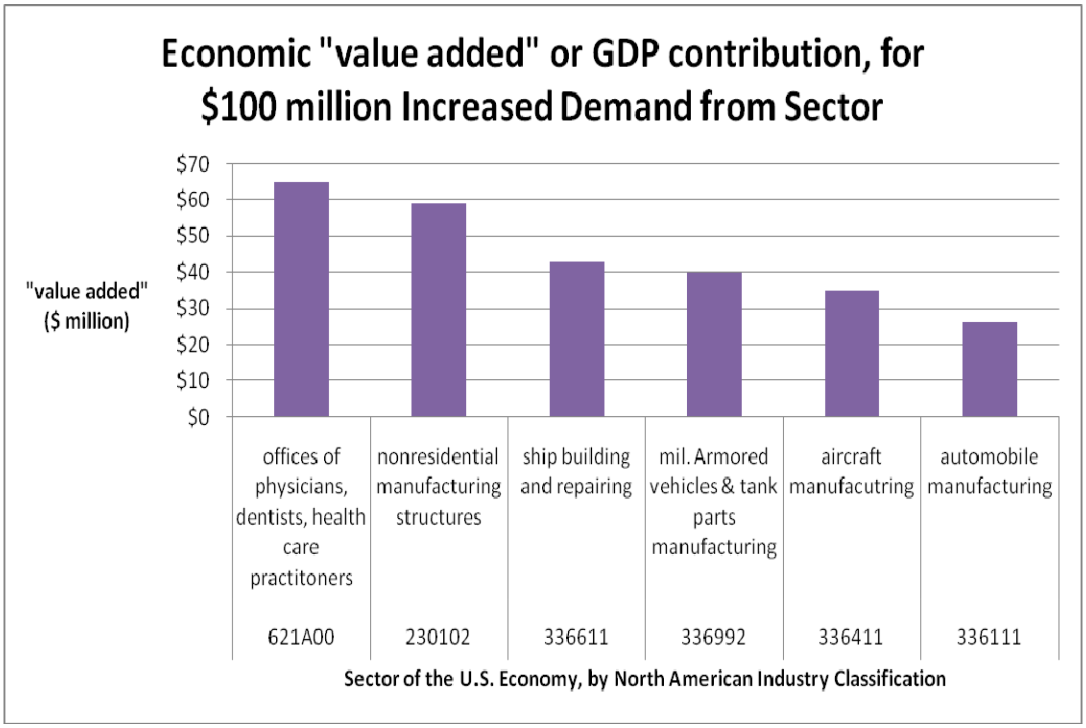

Figure 2. Economic "Value Added" or GDP Contribution, for $100 Million Increased Demand from Sector

In these analyses, shipbuilding and repair "stands out" as a sector which is a very nearly split between the two main factors of production needed to generate additional output—materials and labor (purchases and value added). Whereas automobile and aircraft manufacturing are ranked number one and number two respectively in terms of direct economic effects, this ranking reflects a high degree of automation in their manufacturing processes. Most of the generated direct activity is due to purchases of materials these industries must make in order to manufacture their finished goods.

When the results are analyzed in terms of value added by the industry itself, the ranking of the six sectors considered is nearly inverted. In other words, "offices of physicians, dentists, and health care practitioners" which is first when ranked by value added, was last in total direct effects. Shipbuilding remains in the middle of the group when ranked by value added, since, as a sector, it requires about 57% of materials ($53 million/$100 million), and 43% labor as components of the additional $100 million output. One may conclude that shipbuilding represents a "healthy balance" between these two contributing factors of production, providing stimulation of the economy through both purchases and wages.

Total Economic Effects

For "shipbuilding and repair" a total economic impact of $209 million, as presented in the first row of Table 1 above, represents the total purchases by all other sectors of the economy resulting from an additional $100 million output from shipbuilding and repairing. The $209 million includes the direct purchases made by the shipbuilding and repair sector itself, and also the indirect purchases further up the supply chain; the materials and services needed to produce the goods sold to the shipbuilding and repair sector. Included within the $209 million of activity is the $100 million of increased final output from shipbuilding. Figure 3 below shows how the total $209 million is divided.

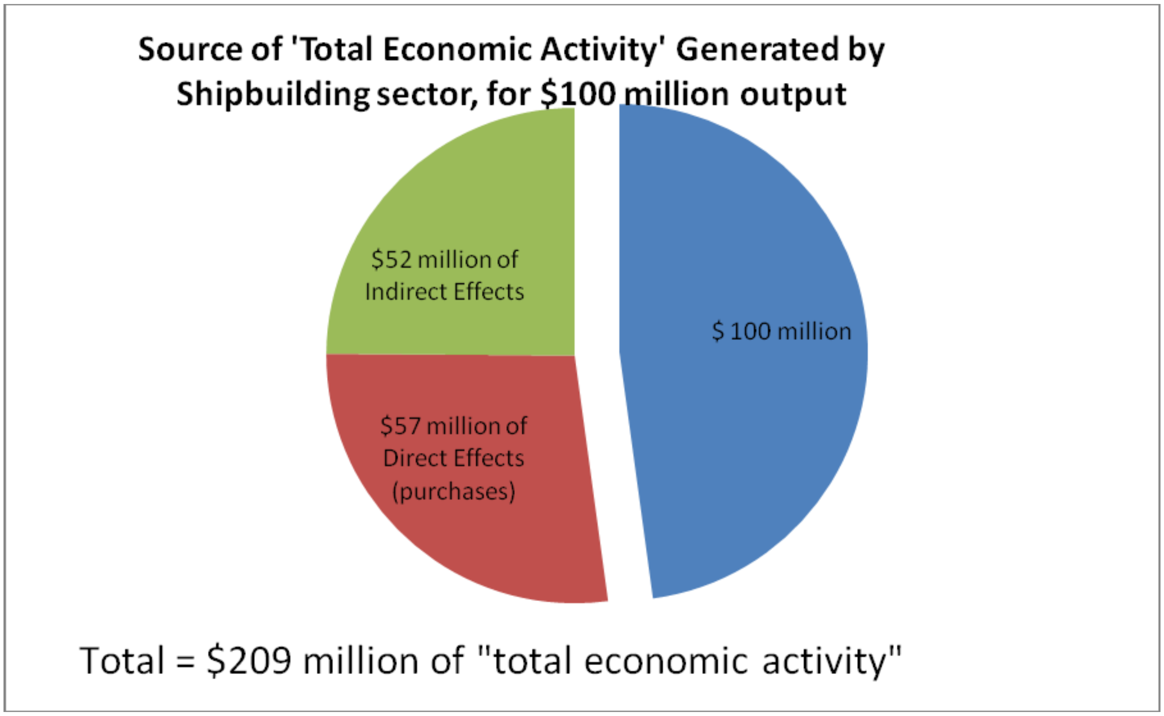

Figure 3. Graphical Representation of the Total and Direct Economic Effects Generated by an Additional $100 Million Output from Six Different Sectors of the US Economy

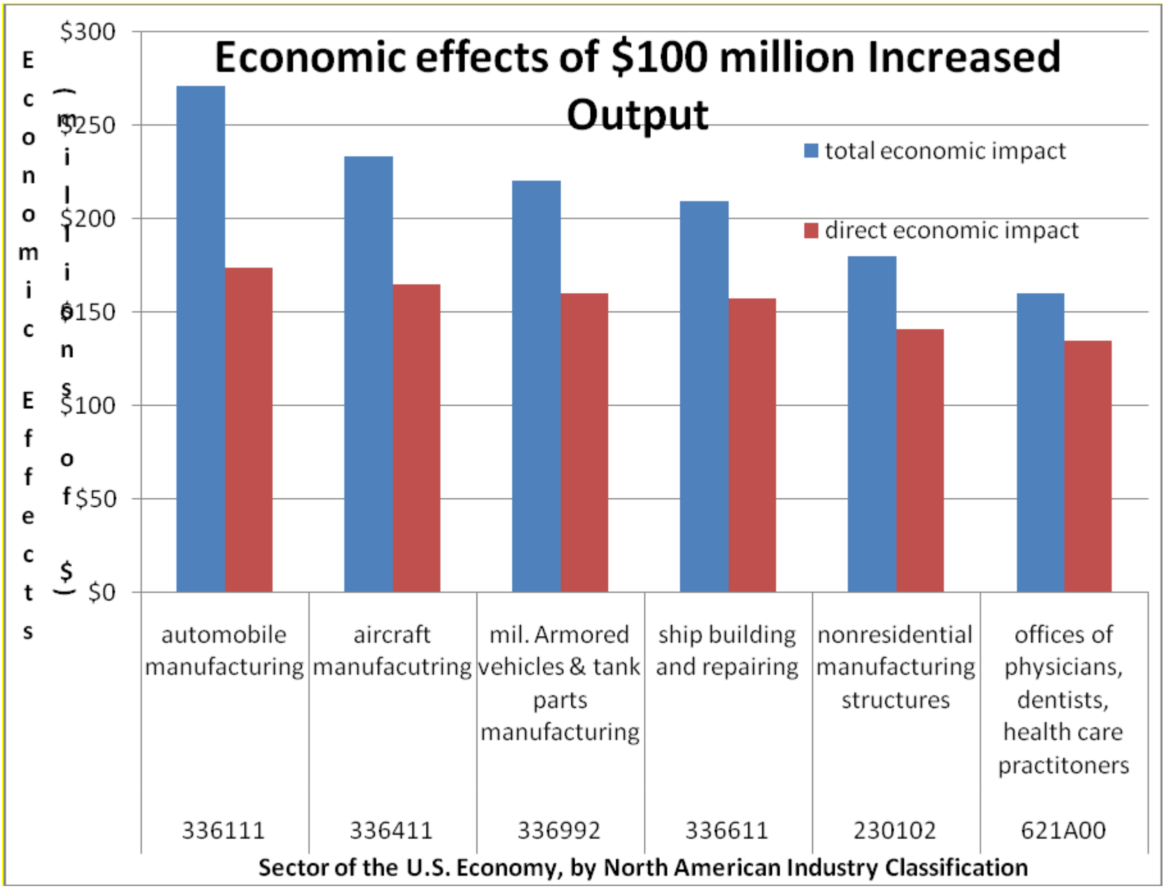

Figure 4. Economic Effects of $100 Million Increased Output

The shipbuilding sector ranks third of the six sectors considered, when ranked by total economic effects, with a multiplier of 2.09 ($209 million/$100 million). Regional economic multipliers for each of the "big six" shipyards may actually be much higher.

Induced Economic Effects

Since $209 million of total economic activity occurs for every $100 million increased output from shipbuilding, the output multiplier, when considering only the impacts within the sector (direct) and the supply chain (indirect) is 2.09. Economists refer to this as a "type I multiplier" (Tessler, 2009). For every $1 of increased output from shipbuilding, about $2.09 of direct and indirect activity occurs.

What this analysis leaves out is the induced effects from the $209 million of activity throughout the economy. The induced impacts are "employment and activity supported by the consumer spending of those employed in the sector or in its supply chain. This helps to support jobs in [US] industries that supply these purchases and includes jobs in retail outlets, companies producing consumer goods and in a range of service industries" (Oxford Economics, 2009). The induced multiplier is the most difficult to calculate or estimate, and the least credible for any industry or sector. Multipliers which include induced effects, economists call "type II multipliers" (Tessler, 2009).

Since the Carnegie-Mellon software does not include induced effects in generating the economic activity results, a type II multiplier is not explicitly calculated using the Leontief inversion process. However, the constant that relates the “Type I and Type II multipliers in an input-output model [has been] proven to be exactly the consumption multiplier for the household sector” (Katz, 1980). The basic consumption multiplier is based on the Marginal Propensity to Consume (MPC) and the tax rate (*t*), and may be calculated as:

$$\frac{1}{1 - MPC\,(1 - t)}$$

An average tax rate of 35% was used, including federal income tax, social security, medicare, and possible state taxes. Assuming a national average marginal propensity to save (savings rate) of 7%, then MPC = 1 – MPS = 93%. The result shows:

$$\frac{1}{1 - 0.93\,(1 - 0.35)} = 2.528$$

The result of using this consumption multiplier estimate to produce type II multipliers is included in Table 4 below.

Table 4.

sector #	Sector	(type I multiplier	minus increased demand)	* consumption multiplier	result -- type II multiplier
336111	automobile manufacturing	2.71	1	2.5	4.28
336411	aircraft manufacturing	2.33	1	2.5	3.33
336992	mil. Armored vehicles & tank parts manufacturing	2.2	1	2.5	3.00
336611	shipbuilding and repairing	2.09	1	2.5	2.73
230102	nonresidential manufacturing structures	1.8	1	2.5	2.00
621A00	offices of physicians, dentists, health care practitioners	1.6	1	2.5	1.50

In reality, differences exist in consumption multipliers between various sectors, but a realistic range is between 2.0 and 3.0, based on tax rates varying by region and MPC varying by profession or trade.

Labor

Using the Carnegie Mellon EIO-LCA Model

Using the Carnegie Mellon EIO-LCA model, the numbers below represent the complete number of employees needed across the supply chain of purchases in order to produce the level of output of $100 million. The US economy-wide benchmark data used for this section is the 1997 benchmark data, since the 2002 model did not include the labor output functionality. *Here the shipbuilding and repair sector ranks 1st of the six considered, with 1670 additional employees needed throughout the supply chain in order to increase shipbuilding output by $100 million.* Again, the model used is a linear model, so an increased output of $1 billion would support 16,700 employees. The next most labor-intensive sector of the six considered is “military armored vehicles manufacturing,” which would utilize 1530 additional employees. ***Of the six specific sectors considered here for possible investments of federal government dollars (to increase that sector’s output),***

"shipbuilding and repair" will create or support the highest number of jobs. The results are shown in Figure 5 below.

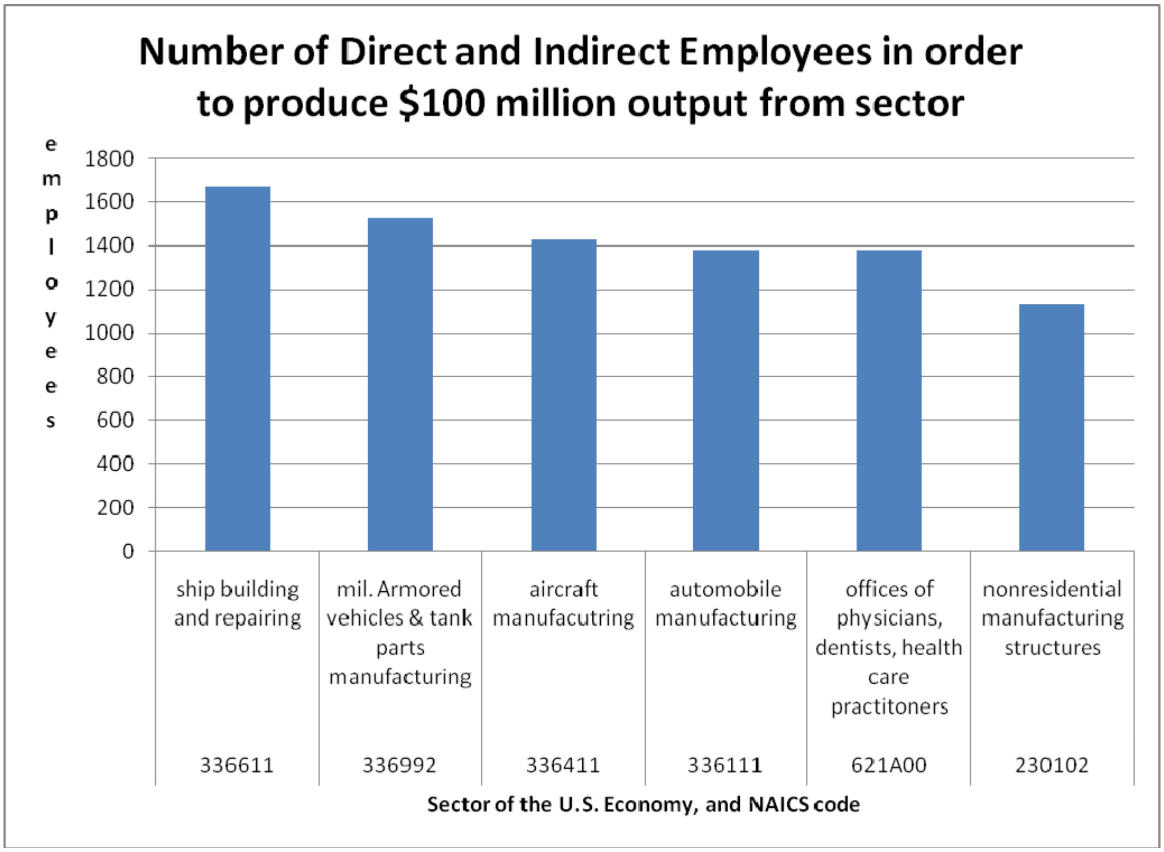

Figure 5. Number of Direct and Indirect Employees in Order to Produce $100 Million Output from Sector

Of the 1,670 jobs created or supported by the shipbuilding and repair sector in order to create an additional $100 million of output, the EIO-LCA model suggests that 918 of those jobs would be within the shipbuilding sector itself, while the remaining 752 would be throughout the supply chain (part of the indirect benefit).

Several assumptions and limitations are associated with the use of the EIO-LCA model to estimate increased employment based on a larger output demand. First, the data is old (1997 benchmark[8]). However, the industries selected are mature industries. Use of the model for information technology or telecommunications estimates would be much less reliable, as these sectors have experienced more widespread growth than shipbuilding, auto/aircraft manufacturing, or health care services. Secondly, the Bureau of Economic Analysis compiles benchmark data through surveys and forms submitted by US corporations to the federal government. Uncertainty in sampling, response rate, and errors in form

[8] The Carnegie Mellon model does not support labor analysis for the 2002 benchmark data. The next most recent year for which benchmark input/output data is available from BEA is 1997.

completion are just a few of the potential sources of discrepancy between the data input and reality.

In addition, the EIO-LCA is a producer price model—"the price a producer receives for goods and services (plus taxes, minus subsidies), or the cost of buying all the materials, running facilities, paying workers, etc." The alternative pricing method, "purchaser price," would includes the producer price plus the transportation costs of shipping product to the point of sale, and the wholesale and retail trade margins (the profit these industries take for marketing and selling the product). For many goods, the producer prices can be far less than what a final consumer would pay (e.g., the producer price for leather goods in US is approximately 35% of the final purchaser price)" (Carnegie Mellon, 2008).

NAVSEA 05C Labor Data Trends

The "05C" office of Naval Sea Systems Command (NAVSEA) provided data for the employment of workers at private shipyards throughout the United States, over the last several decades. The data are presented in Figure 6, which shows a declining trend in the labor force levels at shipyards. As of the beginning of 2009, the nation's "big 6" shipyards directly employed a total of over 56,000 workers. Twenty years ago, in January of 1990, the same yards employed over 80,000 people. In 2000, shipyard labor force levels were even lower than today, reaching about 67% of the 1990 levels. Today, 70% of the number of employees in 1990 are employed throughout the six private shipyards.

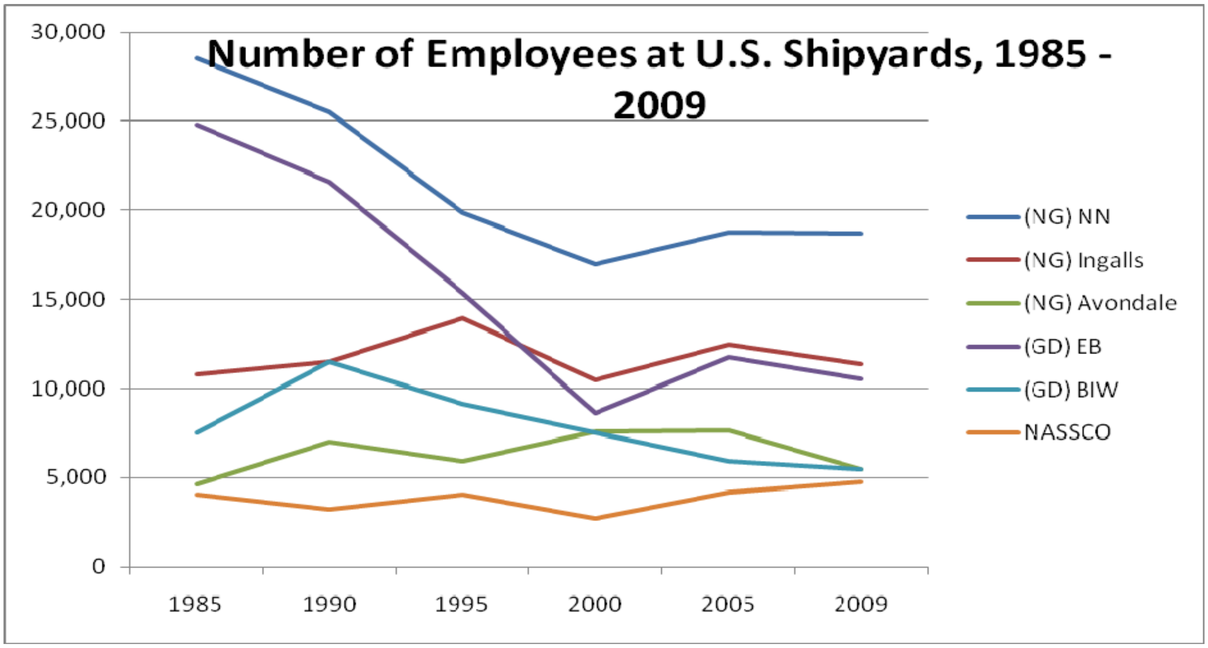

Figure 6. Number of Employees at US Shipyards, 1985-2009
(Source: NAVSEA 05C data file, last updated for all shipyards in 2009)

Figure 7 was produced by NAVSEA 05C's Portfolio Assessment Team, and shows the contribution to state GDP per shipyard worker, compared to the average worker in the state. The results show that in Maine, where Bath Iron Works employees over 5400 workers, on average they contribute more than nine times the income of an average Maine worker.[9]

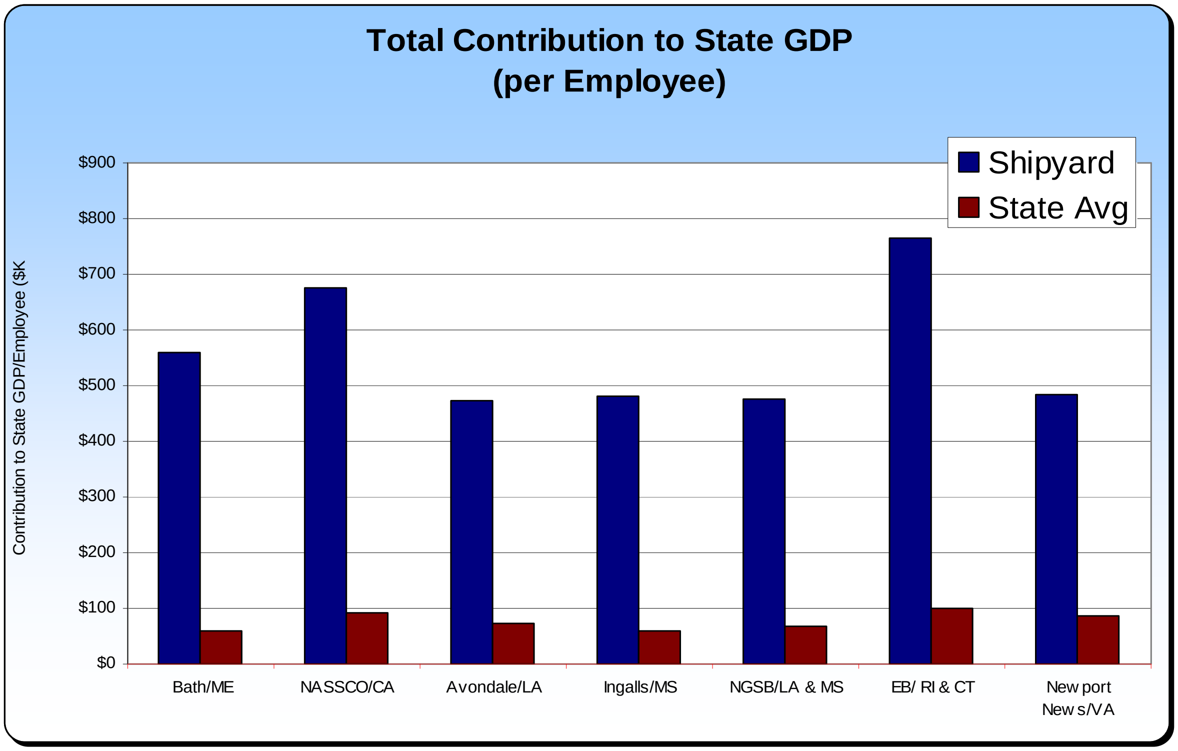

Figure 7. Total Contribution to State GDP

The results of the NAVSEA team's study suggest that shipyard workers contribute between 6 to 9 times more, on average per employee, than the average state worker.

Capital Intensity

Excess Capacity

The sections on Capital Intensity and Excess Capacity are still under development, and will be published upon completion of thesis research in May 2010. Thesis will be available online at http://www.nps.edu/Library/.

[9] Source of average state wage data is the respective state's Bureau of Labor Statistics

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